

2.0 INTRODUCTION, BACKGROUND AND OBJECTIVES

2.1 Introduction

More than two decades of systematic and effective control in California of the precursors to photochemical smog has resulted in a remarkable reduction in ozone concentrations in the South Coast Air Basin, despite an enormous increase in both population and vehicle miles travelled. By any common metric---including peak ozone concentrations, number of first or second stage violations, and seasonal total station hours above the ozone air quality standards---ozone levels in the SoCAB have declined markedly over the past fifteen years (AQMP 1994, Cassmassi 1994).

These improvements in air quality are the result of stringent control programs for both stationary and mobile emission sources mandated by the California Air Resources Board (ARB) and implemented by local air quality management districts such as the South Coast Air Quality Management District (SCAQMD). The dramatic gains made in southern California, particularly over the past decade, stand in sharp contrast to the lack of improvement in ambient ozone concentrations throughout most of the rest of the country (which has generally followed the strategy of controlling only volatile organic compounds (VOC) as advocated by the U.S. Environmental Protection Agency during the 1970's and 1980's). The lack of progress in the eastern U.S. has prompted a reexamination of Federal policy and a call for greater emphasis on control of oxides of nitrogen in other regions of the nation (National Research Council 1991), as well as attention to the role of biogenic hydrocarbons in establishing a potential limit to the effectiveness of anthropogenic VOC control.

Empirical evidence from long-term trend data, for both emission inventories and ambient air quality, indicates that reduction in oxides of nitrogen (NO_x) has been beneficial in reducing peak levels of ozone in the severely impacted downwind regions of the SoCAB. In addition, it is our understanding that photolysis of nitrogen dioxide remains the only significant pathway to ozone formation in the troposphere. Nonetheless, predictions obtained through the use of the Urban Airshed Model (UAM) continue to suggest (AQMP Task Force

1994) that further NO_x control will be counterproductive in reducing ozone over most of the SoCAB. The contradiction between UAM predictions and observed air quality trends has led to suggestions that UAM inputs may not represent high ozone episode conditions over a sufficiently wide range of meteorological conditions. Specifically, much of the regional modeling for the SoCAB has been conducted for one or two pollution episodes, from the Southern California Air Quality Study (SCAQS) conducted in 1987 (SCAQS 1993) or earlier field programs in the SoCAB. It is possible, for example, that reliance on only one or two episodes may lead to difficulties in properly representing the importance of air parcel "residence time" in the SoCAB in the UAM predictions. Moreover, earlier studies of this issue have not accounted for distinctions between weekend and weekday episodes, yet the fraction of total ozone standard violations which occur on weekends has been increasing over the past several years (Cassmassi 1994).

In particular, in recent years, Saturday has been one of the highest ozone days, despite apparently lower VOC and NO_x precursor concentrations (ARB 1993). Because the NO_x inventory is believed to be relatively more reduced on weekends vs. weekdays than is the VOC inventory, it has sometimes been concluded that reductions in NO_x emissions increase ozone, at least in the western portion of the SoCAB. However, it is possible that inclusion of "residence time" in such analyses may show that carry-over effects are largely responsible for the observation of "high" Saturday and "low" Monday ozone levels.

Clearly, there is a need to better characterize the range of meteorological conditions associated with high air pollution episodes and to assess the influence of residence time and weekday/weekend effects on such episodes. Moreover, it is critical to carefully analyze air quality trends in the SoCAB over the past decade on a sub-region basis, and to evaluate correlations between NO₂ and NO_x precursor concentrations and subsequent ozone levels. As described in the following section, such characterizations and assessments have employed as their departure point the important earlier investigations by researchers at Valley Research Corporation (Horie 1987), InstaWeather Inc. (1989), and Systems Applications International (Rosenbaum and Pehling 1991, Stoeckenius 1991), as well as the accumulated knowledge of meteorologists at the ARB and SCAQMD.

2.2 Background

The history of urban airshed modeling for the California South Coast Air Basin is one in which the meteorological conditions of a single ozone episode have been used to forecast the impacts of proposed emission control programs for VOC and NO_x, and to draw fundamental conclusions about the relative efficacy of VOC vs. NO_x control for reducing ozone levels in the SoCAB. For example, Air Quality Management Plans (AQMPs) developed by the SCAQMD in the 1980's generally used a single two-day episode on 26-27 June 1974 as the base case modeling episode. For the AQMP prepared in 1994, the 27-29 August 1987 episode which occurred during SCAQS was used, and several other episodes were also considered.

Reliance on no more than a few episodes is largely a consequence of the complexities and expense of running the Urban Airshed Model in extensive scenario testing and control program evaluations. However, such reliance has raised questions concerning the representativeness of the meteorology of a single episode, given that ozone air quality standard violations in the SoCAB still occur on more than 100 days of the year under a wide range of meteorological conditions. Thus, the SCAQMD's regional modeling and air quality planning efforts have been criticized on this issue (Horie 1987).

In an attempt to address this criticism, a study by Horie (1987) was commissioned by the SCAQMD to develop a set of statistically determined meteorological conditions (*i.e.*, "met classes") that were representative of the long-term meteorology of the Basin. In this study, a Deviation Index (DI) was defined separately for each met class and computed for every individual day during the period from January 1983 through December 1985, in order to systematically measure the suitability of individual days for ozone modeling (Horie 1987). This index was designed to measure a deviation of a particular day's meteorological condition from the average condition for the met-class to which the day belonged.

By examining the emissions, air quality data, and meteorological conditions of the thirteen days having the lowest DI values in each met-class, four candidate days that appeared to be best suited for regional ozone modeling in the SoCAB were selected from

approximately 400 days that were found to belong to one of the four met-classes with basin-maximum ozone concentrations exceeding the Federal ozone air quality standard. Using the same selection procedure, the suitability of three ozone episodes used for regional modeling (26-27 July 1974; 30 August-2 September 1982; 7-8 August 1984) was also evaluated. None of these episode days were found to be representative of any of the four met-classes defined by Horie (1987).

In research building upon the work of Horie, Zeldin conducted a study entitled "A Meteorological and Air Quality Assessment of the Representativeness of the 1987 SCAQS Intensive Days" (Instaweather 1989). In this study, each of the five summer SCAQS episodes and three fall/winter intensive periods were examined with respect to meteorology and air quality. Surface streamlines and sea level pressure were analyzed for three daytime periods, and maps of ozone, nitrogen dioxide, and PM-10 were plotted.

Climatological statistics were found for key meteorological and air quality parameters. These were then compared with the conditions on SCAQS days. Zeldin evaluated the representativeness of the SCAQS summer intensive periods with the methodology developed by Horie. These analyses, along with a special evaluation of intensive day uniqueness, were used to develop a ranking of the SCAQS intensive periods with respect to their suitability for modeling applications.

Zeldin found that only 28 August 1987 had a "reasonable central met-class tendency." None of the other days corresponding to SCAQS intensive episodes had central met-class characteristics. As a consequence of the need to have two consecutive days suitable for modeling, Zeldin ranked the 24-25 June 1987 episode higher than the 27-29 August episode in terms of "overall representativeness" as only the middle day of the three day August episode was judged suitable for modeling.

These findings reinforce the need for further investigations of episode representativeness, and of the influence of factors such as residence time and carry-over as manifest, for example, in weekday/weekend effects.

2.3 Objectives

2.3.1 Overall Objective

The primary overall objectives of this project were: (1) to analyze recent air quality trends in the SoCAB on a sub-regional basis; (2) examine the relationship between ozone levels and NO₂/NO_x concentrations; and (3) to investigate the influence of air parcel residence time and weekday/weekend effects on conclusions drawn concerning the relative benefits of VOC vs. NO_x control in California's South Coast Air Basin.

2.3.2 Specific Objectives

The specific objectives of this project were:

- To characterize recent (*i.e.*, past decade) air quality trends in the SoCAB on a sub-regional basis, including correlations (or lack thereof) between ozone and NO₂ ambient air concentrations.
- To examine the potential importance of distinguishing meteorologically similar high ozone episodes on the basis of whether the occurrence was on a weekend day or a weekday.
- To characterize days above the California state ozone standard by "residence time" and relate this assessment to the meteorological categories developed by South Coast Air Quality Management District (SCAQMD) meteorologists.
- (Exploratory) To evaluate further the meteorological representativeness of the August 1987 SCAQS episode which has been-and will be-used for urban airshed modeling in support of development of VOC/NO_x control strategies and future air quality management plans.
- (Exploratory) To explore multiple linear regression relationships between meteorological parameters and ozone.